Quest Journals
Journal of Architecture and Civil Engineering
Volume 8 ~ Issue 4 (2023) pp: 56-69
ISSN(Online) : 2321-8193
www.questjournals.org

Research Paper

Determinants of Sustainable (Solar) Energy Efficiency in Research Institutes in Kaduna State, Nigeria

[1]Babalola,Olatunde Daniel, [2]Aduwo, Egidario Bridgette, [3]Oti,MarvelousObinna,[4]Amusan, Lekan Murtala, [5]Oloke, Olayinka Clement, [6]Fulani, Omoyeni Aderewa, &[7]Ediae,Osahon James

Corresponding Author:
[1.] Lead Author, Researcher &Senior Lecturer, Dept. of Arch., College of Sc. and Techn. (C.S.T.), Covenant University Ota, Ogun State,Postcode112233, Nigeria;
Lead Author:[1.]Lead Author, Researcher &Senior Lecturer, Dept. of Arch., College of Science and Techn. (C.S.T.), Covenant University Ota, Ogun State, Nigeria.
Co-Authors: [2.] Assoc. Prof.& Researcher, Department of Architecture, C.S.T., Covenant University Ota, Ogun State, Nigeria;
[3.] Practitioner&Researcher associated with Department of Architecture, C.S.T., Covenant University Ota, Ogun State, Nigeria;
[4.] Assoc. Prof. & Researcher, Department of Building Technology, C.S.T., Covenant University Ota, Ogun State, Nigeria;
[5.]Senior Lecturer & Researcher, Department of Estate Management, C.S.T., Covenant University Ota, Ogun State, Nigeria;
[6.] Senior Lecturer & Researcher, Department of Architecture, C.S.T., Covenant University Ota, Ogun State, Nigeria; and
[7.] Lecturer & Researcher, Department of Architecture, C.S.T., Covenant University Ota, Ogun State, Nigeria.

***ABSTRACT**: Solar energy is a renewable form whose importance as a sustainable alternative solution to the perennialenergy crisis in Nigeria, among others cannot be overemphasized. Of the three main classes of renewable energy (hydropower; solar, geothermal, wind; and biomass/combustibles which includes firewood, wastes,etc.)solar energy category is the least developed or utilized despite its inexhaustible potentiality as longas the solar system continues to exist. This study investigated the solar energy efficiency of the research institutes in Kaduna State Nigeria, as well as identified its determinants for beneficial harmonization of methods of improvement. The research technique applied was cross-sectional survey based on randomlyselected sample size of 60 respondents from the two Energy research institutes in the State(located at Kakuri/Kaduna and Zaria). A total of 55 questionnaires were retrieved representing over 91% response rate. Data obtained from the field survey by means of questionnaires were analyzed with descriptive(frequencies and proportions) and inferential statistics (Pearson product-moment correlation and Standard multiple regression analyses) with the aid of IBM SPSS 21 software. Results of data analyses revealed that thestudy population perceived Overall Performance rating of the Solar System in the facilities (buildingsand their environments) or dependent variable (d.v.)to be over 88%, a mean score of 9 on a 10 point scale which is very good. Three predictorswere identified in the study area,with total Adjusted R Square of .744 that explained 74.4 per cent of the residual variation in the d.v. The predictors and their standardized beta coefficients are 'Dependency on Public power supply other than Solar System in the facility (**-3.094**)','energy subsidy through use of the active strategies- solar panel(-**2.582**)', and 'Ages of Respondents (**.322**)'.The study recommended for improvement to the d.v. by reduction in 'dependence on Public power supply in the facilities' andreduction in 'energy subsidy through the use of the active strategies (solar panel)'with corresponding increase in passive strategies, among others for optimum solar energydevelopment.*

***KEYWORDS:** Energyperformance, Predictors, Research institutes, Solar architecture, Sustainable energy*

R**eceived 06 Apr., 2023; **R**evised 18 Apr., 2023; **A**ccepted 21 Apr., 2023 © The author(s) 2023. **P**ublished with open access at **www.questjournals.org

I. INTRODUCTION

The importance of energy efficiency in facilities in Nigeria cannot be over-emphasized because of satisfaction derived in many areas of life- be it for residential, commercial or industrial activities, among others. Inefficiency in energy supply in Nigeria has resulted in low level of industrial sector development, which has also been identified by[1]as the lowest electrification per capita in Africa. Nigeria's electrification rate, according to [2], was less than fifty per cent; and with current Nigeria's estimated population of over 200 million, it is certain that over 100 million persons in the country are generally characterized as without electricity supply. Since the populace spends about 90 per cent of their time within buildings, this makes them to actually experience the plague. Sun is the most reliable, renewable energy resources with daily consistency and is abundant in tropical regions. Being predictable, the energy that can be sourced from the sun is has been estimated as 3.8×10^{23} Kw (equivalent to 1,082,000 ton of oil per day). The solar energy potential is about 4,000 times the daily oil production and 13,000 times the daily natural gas production. Advantages of this great potential have not been explored for people's benefits. By solar architecture (utilization of sun's energy or solar power to fuel a building and/or its surrounding environment) performance and functionality of a facility's design can be enhanced using sun's characteristics.The following research questions were asked for which the study was embarked upon for answers: To what extent was the renewable energy incorporated in the facilities? Whatis the performance rating of solar energy in the facilities? What relationships exist between solar energy efficiency in the facilities and relevant variables; and what are the determinants of solar energy efficiency of research institutes in the study area?The aim of the study was to investigate the solar energy efficiency of the research institutes in Kaduna State Nigeria, with a view to identifying its determinants for beneficial harmonization for improvement. The objectives are to:(i) examine the incorporation of renewable energy in the facilities; (ii) analyze the solar energy performance of the facilities; (iii) establish relationship between solar energyefficiencyin the facilities and relevant variables; and(iv) identify the determinants of solar energy efficiency of research institutes in the study area.

This study is vital to determining the factors that influence the performance of solar energy in the study context. Since solar energy as a renewable type is yet to be explored to beneficial level, the factors can lead to maximization of the subject thereby enhancing the performance, productivity and quality of life of the users. Proposals on new solar energy research institutes can be made by taking positive advantages of the identified factors to enhance the solar energy performance. The findings will suggest ways to mitigate the energy situation by sustainable solution after careful consideration of shortcomings of the unsustainable systems. The study scope covers energy research institutes in Kaduna State Nigeria, which have been identified to be at Kakuri/Kaduna, and Zaria. The facilities and users are involved in the research.

The study area isKaduna State in northern part of Nigeria (Figure 1 and Figure 2)[3 and 4]. It is bounded to the west by Niger State; to the north by Zamfara, Katsina and Kano; to the east by Kano, Bauchi and Plateau; and to the south by F.C.T. and Nasarawa. Located on latitude 10^0 20'N and longitude 7^0 45'E, it has abundant solar resources. Its location possesses potential solar energy with temperaturereaching up to 300F (or over 148^0 C)as a result of intense sunlight.

Figure 1: Map of Nigeria Showing Kaduna State[3]

Figure 2: Map of Kaduna State with the Local Government Areas (L.G.As) and Showing two Energy Research Institutes in Kaduna State: Kakuri/Kaduna and Zaria L.G.As [4]

II.THEORETICAL ISSUES

The primary energy supply systems in Nigeriaknown as public energy supply are classified into: grid system and alternative system. Grid systemhydro-power, thermal power, and grid system distribution and transmission. The Nigerian Power Sector is made up of a network of channels of power embodied in the power grid. The grid composed of generation, transmission and distribution of electricity. Less than 40 per cent of the nation is connected to the power grid- made up of hydro-power, thermal power, and grid system distribution and transmission. The power that is channeled through the grid is generated from hydropower stations and thermal power stations with individual unit capacities and primary resources as water, gas, oil, and coal most of which are fossil fuels. According to [5]the proportion of the different resources are Water (35.6%), gas (39.2%), oil (24.8%), and coal (0.4%); but they are unsustainable being capital intensive, ineffective and has life span due to climate. Hence the need for more sustainable or renewable energy resources. In Alternative System,the over 60 per cent of the population remaining that are unconnected to the grid are still faced with the challenge of electricity usage. The individuals still have to seek for the alternative system to satisfy their demand for electricity, even though such may be unsustainable, but they mitigate energy crisis for those unconnected to the grid. Such include generators and fuel wood [5].Renewable Energy [6]is another form of energy obtained from sources that do not deplete or can be replenished within a human's life time. Renewable energy contribute 13.8 percent of total primary energy supply. Out of this proportion, the contributions are as follows:hydropower (16.5%); solar, geothermal, wind (3.7%); and biomass/combustibles which includes firewood, wastes, etc. (79.8%).Of the three main classes of renewable energy, solar energy category is the least developed or utilized despite its inexhaustible potentiality as long as the solar system continues to exist.

In contrast, the non-renewable sources do deplete with time and such include fossil fuels [7].From literature, determinants of solar energy efficiency of research institutes are those factors that strongly influence can lead to generation of models [8] that could assist directors, managers or policy-makers in managerial decision-making issues in organizations such as the Energy research Institutes being studied. When the a model is rightly derived, it can lead to right decision being taken, while wrong model can lead to wrong decision by focusing on wrong factors or variables. Most times, cross-tabulation analysis of the dependent variable (d.v.) versus each of the predictors are very helpful in finding explanations of their relationship with the d.v.

III.METHODOLOGY

In this section, the research design, the study population, sampling technique, sampling frame, sample size, methods of data collection, and method of analyses were discussed.

3.1 Research Design

The research philosophy adopted in the study is the post-positivist approach, with the use of quantitative and qualitative data[9-11]. The research design[10-12]is such that it enables the research questions to be adequately addressed. Research design is a plan that states the approaches and sources employed in gathering and analyzing data. The study involved a cross sectional survey by means of questionnaire, interview guide, case studies, observations and photographic documentation as data collection instrument. The cross sectional survey was adopted in line with many of the previous studies in literature.

3.2 Fieldwork and Data Collection

3.2.1 Study Population

The study populationconsists of key officers in the two identified Energy Research Institutes in the Kaduna State Nigeria capable of responding to enquiries about the subject being investigated (Table 3.1 column 4).

Table 3:1Study Population, Sampling Frame and Sample Size[16]

SN	Location in Kaduna State	Energy Research Institute	Study Population	Sampling Frame	Calculated Sample size	Actual Sample size	Retrieved
1	Kakuri/Kaduna	Blue Camel Energy Research Academy and Solar Assembly Plant	20	20	8	**15**	**15**
2	Zaria	Centre of Energy Research and Training	60	60	25	**45**	**40**
		Total	80	80	33	**60**	**55**

3.2.2 Sampling Technique

This is the method of sampling adopted in order to select suitable elements to be studied from the whole study population. Two of the three Energy Research Institutes in the North were randomly selected from location ordered list for the sampling frame; each selected research institute was stratified into 'Top Management (MD & Director) and Other Officers (such as Facility Managers & Maintenance Officers)'. Systematic random sampling was used for the actual sample size to which the questionnaires were administered- With first questionnaire administration done randomly to any person in the stratum, second, third, fourth, fifth, etc. questionnaires were administered to third, fifth, seventh, ninth, etc. persons respectively, and following established standard procedure until the prepared questionnaires were exhausted.

3.2.3 Sampling Frame and Sample Size

The sampling frame was made up of the two Research Institutes in Kaduna State Nigeria (Table 3.1 column 5). They are made up of Blue Camel Energy Research Academy and Solar Assembly Plant, Kakuri/Kaduna, and Centre of Energy Research and Training, Zaria.

The sample size was calculated using sample size formulae, using an alpha level of .05 for continuous variables and acceptance margin of error of .03[12-15]. Since the variables of interest are based on ten-point Likert Scale, the first sample size 'S' based on the standard formula is:

$$S = (t^2 \times s^2)/d^2 \quad (1)$$

where,

t = value of selected alpha level of .025 in each tail = 1.96 or 2.00 if population does not exceed 120 (the alpha level of .05 indicates the level of risk the researchers are willing to take that the true margin of error may exceed the acceptable) (Bartlett, Kotrlik, and Higgins, 2001)

s = estimate of standard deviation in the population = estimate of variance deviation for 10-point scale divided by 9 (number of standard deviations in range)= 10/9 = 1.111

d = acceptable margin of error for mean being estimated (number of points on primary scale (10) x acceptable margin of error (.03)) = 10 x .03 = .3

$$S = (t^2 \times s^2)/d^2 = (2.00)^2 \times (1.111)^2/ (10 \times .03)^2 = 4.00 \times 1.2343 / .09 = 55$$

But since 'S' is greater than five per cent of the study population (80), the second sample size correction formula for finite size was applied for S_1:

$$S_1 = S/ [1 + (S/Population)] = 55/ [1 + (55/80)] = 33 \quad (2)$$

The calculated sample size 'S_1' is 33. But in anticipation of low response rate based on similar previous studies, the actual sample size used was increased by over 80% of the calculated sample size (S_1) to 60.

The number of persons to be interviewed based on existing literature was to be at least five per cent of the 'actual sample size used' randomly selected. Twenty-five per cent (25%) respondents were initially proposed for interview, but since this is higher than five per cent of the respondents, it was calculated by using the correction formula to 12.

3.2.4 Reliability and Validity of the Research Instruments

Pilot study was carried out few weeks to the final field survey to determine reliability and validity of the research instruments, potential problems on the field as well as acquaintance with expectations from the field. Cronbach's alpha coefficient is one of the indicators for reliability. In the reliability test carried out on the Questionnaire as a research instrument, Cronbach's alpha coefficient was .88, which is higher than the acceptable minimum of .70[15]. Since it is known that there is a direct relationship between reliability and validity, both of them have been found to be satisfactory by this research instrument and by implication, the research instrument has good internal consistency.

3.2.5Data Collection Instruments

Data were generated from primary sources, and aided with secondary sources. The primary sources were from questionnaire, interview and observations. The questionnaire was specially designed structured to obtain information from the facilities users. It is made up of four sections: users' bio-data, solar architectural characteristics of the building and environment, indicators of energy performance of the building and environment, and last part was the open-ended question. The questionnaire was structured to obtain answers to research questions from respondents. Interview Guide was designed based on outcome of pilot study to obtain information from users on their opinion about some factors and general issues. Physical observation was also made on the facilities to obtain primary data on the buildings fabrics, and surrounding environment with the aid of photographic instruments.The secondary sources were from relevant journal articles, magazines, books, and other information such as maps were obtained from different websites.

3.2.6 Methods of Data Collection and Analyses

The actual fieldwork was carried out by means of the research instruments- the questionnaire, interview guide and observation schedule. In December 2018, the pilot study was carried out, while the main data were collected inJanuary and February 2019. For the fieldwork, the research instruments were administered by one of the researchers and three research assistants to the sample size during working days (between Mondays to Fridays).

Data Collected through questionnaire were analyzed with computers by means of IBM SPSS 21. Descriptive analysis was used for Interview. Results of analyses are properly documented in appropriate section based on objectives.

IV. RESULTS, FINDINGS AND DISCUSSION

In this section, the result of analyses on field data was presented based on the objectives of the study.Of the 60 questionnaire administered, 55 were retrieved representing 91.67 percent response rate which was considered satisfactory. Majority of the population over 61% were highly educated, married malesof ages not more than 40 years. They all had not more than 10years job experience, with majority professionally affiliated to environmental sciences (Architecture, Building Technology, Estate Management and Quantity Surveying) rather than engineering, earning less than Fifty Thousand Naira (₦ 50,000) and more or less middle level (maintenance officer and facility managers)rather than top management staff- Managing Directors and Directors (Table 4.1 in Appendix 2, Items 1-9).

4.1 Incorporation of the Renewable Energy in the Facilities

Majority (over 72%) of the study population identified(Table 4.2):

(i) incorporation of any or all of the stated solar energy main conversion processes in their facility as 'electrical' rather than as 'Thermal wall and Bio-chemical'.

(ii) incorporation of Solar system or other renewable energy in their facility as 'Active' rather than Passive or None.

(iii) incorporation of Solar collector in the Wall of buildings (while the remaining are in Roofs).

(iv) incorporation of Solar collector in the Surrounding or Neighborhood in 'Vertically mounted or inclined as in Wall' (while the remaining are Laid on or near the ground at a height below 2.1m).

Table 4.2: Incorporation ofthe renewable energy in the Research Institutes[16]

Variable	Frequency (N= 55)	Proportion (Per cent %)
1. Identify incorporation of any or all of the stated solar energy main conversion processes in your facility:		
Thermal wall & Bio-chemical	0	0.0
Electrical	55	100.0
2. Identify incorporation of Solar system or other renewable energy in your facility:		
Passive or None	0	0.0
Active	55	100.0
3. Identify incorporation of Solar collector in your building:		
Wall	40	72.7
Roof (Exposed Floor, Terrace or Balcony& None = Nil)	15	27.3
4. Identify incorporation of Solar collector in the Surrounding or Neighborhood:		
Laid on or near the ground at a height below 2.1m& Others[Mounted on Roof or Car Parks or in open area(s) at a height not less than 2.1m, or None = Nil]	15	27.3
Vertically mounted or inclined as in Wall	40	72.7

4.2 Solar Energy Performance of the Facilities

All the study population perceived Performance rating of Solar System in the facilities (buildings and their environments) (Table 4.3)as at least eight (8) on a scale of 10; while the majority (over 92%) of the study population perceived Overall Performance rating of Solar System in the facilities (buildings and their environments) as at least nine (9) on a scale of 10. The Overall Performance of Solar System in the facilities had a mean score of 8.88 on a scale of 10.00 or 9 on a scale of 10, which is perceived as very high; even though there is still room for improvement by raising the raw mean score to 10.00 or achieving 100% performance rating.

Table 4.3: Solar energy performance of the facilities [16]

Variable	Frequency (N= 55)	Proportion (Per cent %)	Mean Score (10.0000)	Final Mean Score (10)
Overall Performance rating of Solar System in your facility (building and environment):				
10% & Below	0	0.0		
11-20%	0	0.0		
21-30%	0	0.0		
31-40%	0	0.0		
41- 50%	0	0.0		
51-60%	0	0.0		
61-70%	0	0.0		
71-80%	*4*	*7.3*		
81-90%	*26*	*47.3*	8.8818	9
91-100%	*25*	*45.5*		

4.3 Relationship between Solar Energy Efficiency in the Facilities and Relevant Variables

The relationships between solar energy efficiency in the facilities and 20 relevant independent variables (i.vs) drawn from 'Users Bio-data, Solar Architecture Characteristics of the Building and Environment, and literature based Indicators of Energy Performance of the Building and Environment' were investigated using Pearson product-moment correlation analysis. Preliminary analysis was carried out to ensure no violation of the assumptions of normality, linearity and homoscedacity.

Table4.5: Relationship between solar energy efficiency in the facilities and relevant variables (Pearson Product-moment correlation) [16]

SN	Variable	Correlation Coefficient with Satisfactory Sig.	Remark
1	Dependency on Public power supply other than Solar System in your facility	- .661	High Correlation
2	Scale of preference of Solar System in your facility	.613	
3	Regularity of Solar System in your facility	.613	
4	Identify incorporation of Solar collector in your building	.613	
5	Main source of electricity power for your facility	.613	
6	Secondary source of electricity power for your facility	.613	
7	Location of your main power source for your facility (building and environment)	.613	
8	Scale of preference of Public power supply other than Solar System	-.613	
9	Regularity of Public power supply other than Solar System	-.613	
10	Identify incorporation of Solar collector in the Surrounding or Neighborhood	-.613	
11	Length of Stay in the organizations (year)	-.613	
12	Age of respondent (years)	.591	
13	How much energy is subsidized through the use of the active strategies (solar panel)	.572	
14	Dependency on Solar System in your facility	.564	
15	Average Monthly Income (Naira)	-.482	Medium Correlation
16	Occupation of respondents	.431	
17	Overall Performance rating of Public Power supply other than Solar System in your facility (building and environment)	-.402	
18	Reliability of Public power supply other than Solar System in your facility [Pearson Correlation = -.193, Sig. (2-tailed).= .158]	-	No Correlation
19	Reliability of Solar System in your facility [Pearson Correlation = -.084, Sig. (2-tailed).= .541]	-	
20	Energy conserved through the use of the passive strategies [Pearson Correlation = -.076, Sig. (2-tailed).= .582]	-	

Results (Table 4.5 from Table 4.4 in Appendices 3) showed that:
(i) There was strong positive correlation between solar energy performance and nine (9) variables, with r= .564 to .613, n= 55, p= .0005, with high levels of solar energy associated with high levels of the nine (9) i.vs. (ii) There was strong negative correlation between solar energy performance and five (5) variables, with r= -.613 to -.661, n=55, p= .0005, with high levels of solar energy associated with (absolute value of) high levels of the five (5) i.vs.
(iii)There was medium positive correlation between solar energy performance and one (1) variable, with r= .431, n= 55, p= .0005, with high levels of solar energy associated with medium level of the one (1) i.v.
(iv) There was medium negative correlation between solar energy performance and two (2) variables, with r= -.402 and-.482, n= 53 to 55, p= .0005, with high levels of solar energy associated with (absolute value of)medium levels of the two (2) i.vs.
On the whole 17 indicators showed significant association with solar energy performance, 14 have high correlation coefficients with r= + or – (.564 to .661) and three (3) have medium correlation coefficientswith r= + or – (.402 to .482).

4.4Determinants of Solar Energy Efficiency of Research Institutes in the Study Area

For identification of the factors influencing solar energy efficiency of research institutes in the study area as the dependent variable (d.v.), Standard Multiple regression (SMReg) analysis was conducted on the 17 identified variables with significant degrees of association from correlation analysis in the preceding section.Preliminary analysis was carried out on the data to ensure that there is no violation of the assumptions of normality, linearity, multicollinearity and homoscedacity. In preparation for final analysis, preliminarypaired SMReg'forced entry and stepwise entry' of the i.vs resulted in reduction of number of indicators to six (6), which falls within acceptable standard ratio of 'one (1) i.v. to minimum of five (5) and maximum of ten (10) observations' [12 and 15].

Table 4.6: Standard multiple regression (model summary)from forced entry [16]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.889[a]	.790	.769	.29976	.790	36.902	5	49	.000

b. Dependent Variable: Overall Performance rating of Solar System in your facility (building and environment)

Result of SMReg 'forced entry of the six (6) i.vs against the d.v. (Table4.6, 4.7 and 4.8) is summarized as F[(5, 49) = 36.902, p = .000], R Square = .790 and Adjusted R Square = .769. The coefficient of determination Adjustable R Square value of .769.

Table 4.7: Standard multiple regression (ANOVA)from forced entry [16]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	16.579	5	3.316	36.902	.000[a]
	Residual	4.403	49	.090		
	Total	20.982	54			

b. Dependent Variable: Overall Performance rating of Solar System in your facility (building and environment)

Result of SMReg 'forced entry' of the i.vs showed that they altogether explained 76.9 per cent of the residual variation in the d.v.Only three (3) of the i.vs (Tables 4.6- 4.8) made significant contribution to the residual variation in the d.v. with each having a sig. value of less than .03.
Result of SMReg 'stepwise entry' of the i.vs (Table 4.9 and Table 4.10) showed that only those three variables (that made significant contribution from forced entry output) with Adjusted R Square of .744 explained 74.4 per cent of the residual variation in the d.v.Only three (3) of the i.vs (Table 4.9) made significant contribution to the residual variation in the d.v. with each having a sig. value of less than .03.
Based on Adjusted R Square (R^2) change, the Model Summary (Table 4.9 and Table 4.10) revealed that Dependency on Public power supply other than Solar System in your facility (.426), How much energy is subsidized through the use of the active strategies (solar panel) (.232), and Age of Respondents (.086) are the three (3) predictors of d.v. in the study area.

Table 4.8: Standard multiple regression (coefficients)from forced entry [16]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	20.191	3.907		5.168	.000	12.340	28.041					
	Age of Respondents	***.473***	***.122***	***.302***	***3.884***	***.000****	***.228***	***.718***	***.591***	***.485***	***.254***	***.708***	***1.413***
	Identify incorporation of Solar collector in the Surrounding or Neighbourhood:	-2.246	1.331	-1.619	-1.687	.098	-4.921	.430	-.613	-.234	-.110	.005	215.192
	How much energy is subsidized through the use of the active strategies (solar panel)	***-.547***	***.139***	***-3.482***	***-3.924***	***.000****	***-.827***	***-.267***	***.572***	***-.489***	***-.257***	***.005***	***183.785***
	Dependency on Public power supply other than Solar System in your facility	***-.458***	***.078***	***-2.836***	***-5.903***	***.000****	***-.614***	***-.302***	***-.661***	***-.645***	***-.386***	***.019***	***53.905***
	Dependency on Solar System in your facility	-.087	.051	-.468	-1.705	.094	-.190	.016	.564	-.237	-.112	.057	17.611

a. Dependent Variable: Overall Performance rating of Solar System in your facility (building and environment)

Table 4.9: Standard multiple regression (model summary)from stepwise entry [16]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.661[a]	.436	.426	.47232	.436	41.051	1	53	.000
2	.819[b]	.671	.658	.36452	.234	36.983	1	52	.000
3	.871[c]	.758	**.744**	.31525	.088	18.524	1	51	.000

d. Dependent Variable: Overall Performance rating of Solar System in your facility (building and environment)

Table 4.10: Standard multiple regression (coefficients)from stepwise entry [16]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	10.148	.136		74.886	.000	9.876	10.420					
	Dependency on Public power supply other than Solar System in your facility	-.107	.017	-.661	-6.407	.000	-.140	-.073	-.661	-.661	-.661	1.000	1.000
2	(Constant)	15.158	.830		18.254	.000	13.492	16.824					
	Dependency on Public power supply other than Solar System in your facility	-.574	.078	-3.551	-7.369	.000	-.730	-.417	-.661	-.715	-.586	.027	36.677
	How much energy is subsidized through the use of the active strategies (solar panel)	-.460	.076	-2.931	-6.081	.000	-.612	-.308	.572	-.645	-.484	.027	36.677
3	(Constant)	*13.466*	*.819*		16.448	.000	11.823	15.110					
	Dependency on Public power supply other than Solar System in your facility	*-.500*	*.069*	*-3.094*	*-7.193*	*.000*	*-.639*	*-.360*	*-.661*	*-.710*	*-.495*	*.026*	*39.060*
	How much energy is subsidized through the use of the active strategies (solar panel)	*-.405*	*.067*	*-2.582*	*-6.080*	*.000*	*-.539*	*-.272*	*.572*	*-.648*	*-.418*	*.026*	*38.065*
	Age of Respondents	*.505*	*.117*	*.322*	*4.304*	*.000*	*.269*	*.741*	*.591*	*.516*	*.296*	*.845*	*1.184*

a. Dependent Variable: Overall Performance rating of Solar System in your facility (building and environment)

Table 4.11: Determinants and their codes

Model	Factors	Code
1	Dependency on Public power supply other than Solar System in your facility	DEPPUBPOW
2	How much energy is subsidized through the use of the active strategies (solar panel)	ENERGSUBSAS
3	Age of Respondents	AGERES

For equation of optimum regression, the stepwise algorithm was carried out (based on Tables 4.9 and 4.10) in a way that the i.vs entered according to their contribution to the model. The contribution of each of the predictors was measured by Adjusted R Square (R^2) change value, which showed a steady increasein coefficient of determination and decrease in standard error of the estimate. The least square algorithm applied to the model is as shown in these equations:

$$Y = \beta_0 + \beta_1 V_1 + \beta_2 V_2 + \beta_3 V_3 + E \quad (3)$$

(where, Y is the dependent variable, $\beta_0$is the constant of the model, β_0, β_1, β_2, $\beta_3$are regression coefficients, V_1, V_2,V_3 are the predictors, and E is the error component in the model), which gives the resultant estimated equation of the model as

$$Y= 13.466+ (-.500)* DEPPUBPOW +(-.405)* ENERGSUBSAS +(.505)* AGERES+.819 \quad (4)$$

$$Y= 14.285 + (-.500)* DEPPUBPOW + (-.405)* ENERGSUBSAS + (.505)* AGERES \quad (5)$$

The unique contribution of each of the three predictors of the d.v.in the study area based on standardized *beta* coefficients (in parenthesis) and Table 4.9are: Dependency on Public power supply other than Solar System in your facility (***-3.094***); How much energy is subsidized through the use of the active strategies (solar panel) (***-2.582***); and Age of Respondents (***.322***).

To find explanation for the outcome of the SMReg, cross-tab analysis (not shown) was carried out on Overall Performance rating of Solar System in the facilities (building and environment) as the d.v. versus the three (3) predictors.

Although the d.v. had a mean score value of 8.88/10.00 (Table 4.3),for it to be enhanced to 10.00/10.00, Dependence on Public power supply (other than Solar) System in the facilities(with a mean score value of 7.18/10.00) must be minimized to 1.00/10.00; Energy subsidy through the use of the active strategies (solar panel) in facilities (with a mean score value of 3.60/10.00) must be minimized to 1.00/10.00; Age of Respondents in facilities (with a mean score value of 1.91/3.00) must be increased to 2.00/3.00.

From the cross-tab, the age range of the respondents influences their perception of the measures of the d.v. such that as the 12.7% of the respondents of age range '20 years and below' becomes older and enter the age bracket 21-40 years where 83.6% of them currently belong, their perception will increase. However, as they cross this age range to 41-60years, there is a decline. Hence the optimum age range for highest perception of the d.v. is when all respondents are in age bracket 21-40 years (see Appendix 2).

V. INTERVIEW

Based on literature and outcome of correlation analysis of dependent variable (d.v.) with relevant independent variables (i.vs.) from pilot study, the Interview Guide was designed to obtain opinion of respondents during full field survey on some variables with significant degrees of association. This was done for confirmation whether or not they are perceived as likely influencers of the d.v.

Table 4.12: Summary of responses to interview questions [16]

SN	Variable	No Influence		Positive or Negative Influence		Inference
		Frequency	Proportion (%)	Frequency	Proportion (%)	
1	***Overall Performance rating of Public Power supply other than Solar System in your facility (building and environment):***	3	25.00	***9***	***75.00****	***Likely determinant***
2	***Reliability, Regularityor Dependency on Public power supply other than Solar System in your facility***	5	41.67	***7***	***58.33****	***Likely determinant***
3	Reliability, Regularity or Dependency on Public power supply other than Solar System in your facility	7	***58.33***	5	41.67	-
4	Identify incorporation of Solar collector in your building and Surrounding or Neighborhood:	8	***66.67***	4	33.33	-
5	***Energy is subsidy through the use of the active (solar panel) or passive strategies***	5	33.33	***7***	***58.33****	***Likely determinant***
6	Energy conservation through the use of the active or passive strategies	9	***75.00***	3	25.00	-

Five (5) of the respondents were females, while seven (7)of them were males. Their responses to six (6) key issues summarized in Table 4.12 revealed that three (3) of them were identified each by majority (over 50%) as likely determinants (Items 1, 2, and 5). The findings seems to be in agreement with SMReg analysis result in Section 4.4 that showed that only three factors are the predictors of the d.v.; with the highest predictor (Dependency on Public power supply other than Solar System in your facility) coinciding with Item1 (Table 4.12), while the second highest predictor (How much energy is subsidized through the use of the active strategies (solar panel) was drawn from Item5 (Table 4.12). Other prominent suggestion is that dependence on Solar energy system should be enhanced as performance of Public power supply has been very low.

VI. CONCLUSION

Results of data analyses revealed that Majority (over 61%) of the study population were highly educated, Married or Separated males, of Ages 40 years and below, and whose experiences are 10years and below. Majority (over 72%) of the study population identified incorporation of Solar collector in the Wall of buildings and in the Surrounding or Neighborhood in 'Vertically mounted or inclined as in Wall'.The study population perceived Overall Performance rating of Solar System in the facilities (buildings and their environments) as over 88%, a mean score of 9. There were strong (positive or negative) correlation between solar energy performance and fourteen (14) variables; and also medium (positive or negative) correlation between solar energy performance and three (3) variables. Three predictors of the Overall Performance rating of Solar System in the facilities (d.v.) in the study area with their standardized *beta* coefficients are 'Dependency on Public power supply other than Solar System in the facility (***-3.094***)', 'energy subsidy through the use of the active strategies (solar panel) (***-2.582***)', and 'Ages of Respondents (***.322***)'.For development and improvement of Overall Performance rating of Solar System in the facilities (d.v.) in the study area, the following recommendations were made:

1.There must be deliberate reduction in 'dependence on Public power supply in the facilities'.
2. There must be significant reduction in 'energy subsidy through the use of the active strategies (solar panel)'with corresponding increase in passive strategies, among others.
3. The more the Institutes approach 100% attainment of 'Age range 21-40years' of key officers from current 83.6% the higher their comprehension and perception of the Overall Performance rating of Solar System in the facilities (d.v.) in the study area.
4. In spite of the high (90 per cent or 9/10) reliability of solar energy there was low (40 per cent or 4/10) dependence on it. There must be conscious reversal of this by increasing the dependence on it and corresponding reduction in dependence on public energy supply.
5. Also since solar energy category is the least developed or utilized despite the great potentialities of the components, there is need to consciously and greatly explore the development of this category of renewable energy for contribution tosustainability of planet earth.

CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the Proprietor of Covenant University Otafor support through provision of enabling environment for this study. They also want to thank all researchers, authors and editors of books and journals, as well as other sources of information that were contributory to this research work.

AUTHORS' CONTRIBUTIONS

Title, Abstract, Introduction, Part Literature Review, and general Overview of the Sections, Part Fieldworks, Analysis and Acknowledgements - Babalola, Olatunde Daniel, Aduwo, Egidario Bridgette, Obinna, Oti Marvelous, andEdiae, Osahon James. Research Method, Part Literature Review, Part Fieldworks, Analysis, Findings, Conclusion (including Recommendations) and References - Obinna, Oti Marvelous,Amusan, Lekan Murtala, Oloke, Olayinka Clement, Fulani, Omoyeni Aderewa, and Ediae, Osahon James.

REFERENCES

[1]. Olaoye T., Ajilore T., Akinluwade K., Omole F., and Adetunji A. (2016). Energy Crisis inNigeria : Need for Renewable Energy, In American Journal of Electrical and Electronic Engineering4(1), 1–8. https://doi.org/10.12691/ajeee-4-1-1

[2]. Olatunji O., Akinlabi S., OluseyiA., Abioye A., Ishola F., Peter M., and Madushele N. (2018). Electric Power Crisis in Nigeria: A Strategic Call for Change of Focus to Renewable Sources. IOP Conference Series: Materials Science and Engineering, 413(1). https://doi.org/10.1088/1757-899X/413/1/012053

[3]. Map of Nigeria and States, Retrieved from google.com.ng

[4]. Map of Kaduna State with the Local Government, Retrieved from google.com.ng

[5]. Kennedy-DarlingJ.,HoytN., Murao K. and Ross A. (2008). The Energy Crisis of Nigeria: An Overview and Implications for the Future. The University of Chicago

[6]. Szokolay S.V. (2008). Introduction to Architectural Science: The Basis of Sustainable Design, Second Edition. New York: Elsevier

[7]. Frewin C. (n.d). Renewable Energy Retrieved from https://www.studentenergy.org/topics/renewable-energy

[8]. Babalola O.D.,Ibem E.O., Olotuah A.O., Opoko A.P., Adewale B.A., and Fulani O.A. (2020). Housing Quality and its Predictors in Public Residential Estates in Lagos, Nigeria, In Environment, Development and Sustainability. Received: 11 August 2018 / Accepted: 29 April 2019, Published Online 14 May, 2019 © Springer Nature B.V. 2019 https://doi.org/10.1007/s10668-019-00367-8 Published Hardcopy 14 May, 2020

[9]. IbemE.O. and Amole D. (2011).Assessment of the qualitative adequacy of newly Constructed public housing in Ogun State, Nigeria Property Management, 29 (3), 2011, 285-304. DOI 10.1108/02637471111139437

[10]. IbemE.O. Oni O.O., Umoren E. and EjigaJ. (2017). An Appraisal of Universal Design Compliance of Museum Buildings in Southwest Nigeria, International Journal of Applied Engineering Research, 12(23), 2017, 13731-13741.

[11]. Ibem E.O., Opoko A.P., Adeboye A.B. and Amole D.(2013). Performance evaluation of residential buildings in public housing estates in Ogun State, Nigeria: Users' satisfaction perspective. Frontiers of Architectural Research, 2, 2013, 178–190.

[12]. Bartlett J.E., Kotrlik J.W., and Higgins C.C. (2001). Organizational Research: Determining Appropriate Sample Size in -Survey Research. Information Technology, Learning and Performance Journal, 19 (1), Spring 2001, 43-50.

[13]. Odukoya D. and Oludotun O. (2007). Research Methodology-Guidelines for Undergraduate Students, (Nigeria: University of Lagos, 2007).

[14]. Ojo, O. (2005). Fundamentals of Research Methods, Lagos Nigeria: Standard Publications

[15]. Pallant, J. (2011). SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS, Fourth Edition, Australia: Allen and Unwin, 2011

[16]. Authors' Fieldwork. (2019). Fieldwork in Kaduna State Nigeria and/or subsequent Analyses

APPENDICES

Appendix 1: Grid system in Nigeria

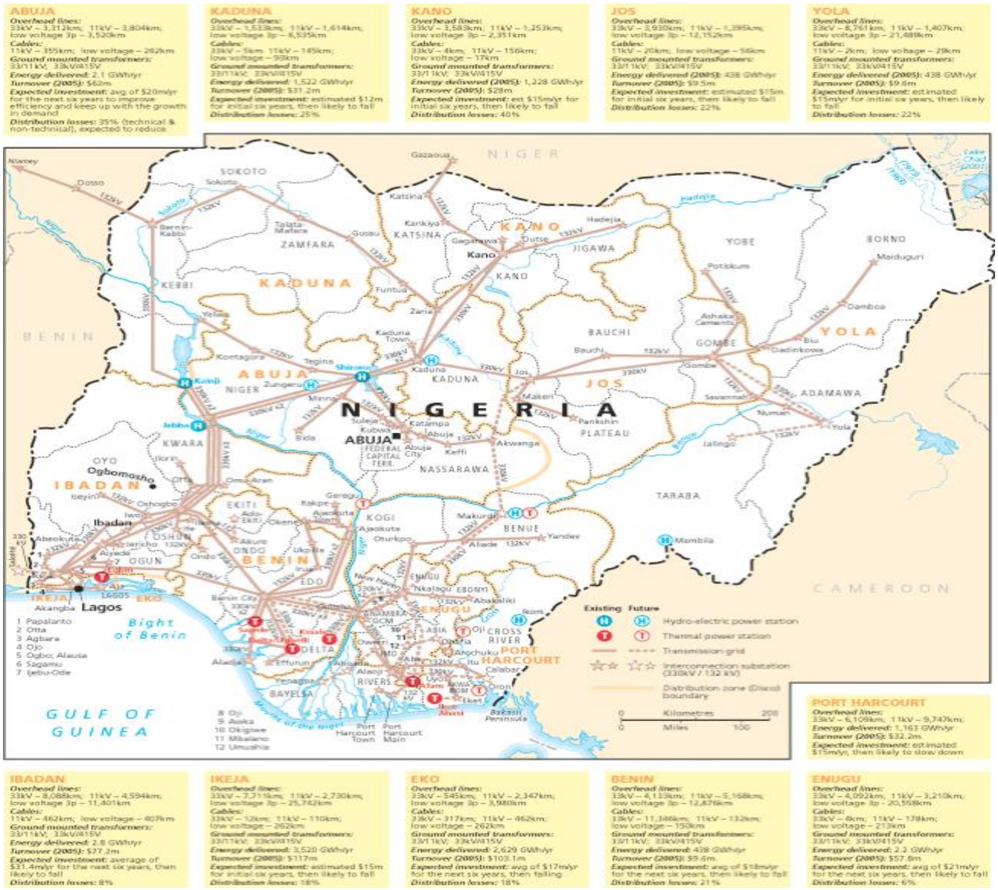

Figure 3: Map on Grid system in Nigeria [5]

Appendix 2: Findings

Table 4.1: Findings on variables [16]

S N	Description	Frequency 55	Per cent %	Scale Max= 10	Mode Max= 10	Score Mean Max= 10.0000	Final Mean Max= 10
	SECTION A: USERS BIO-DATA						
1	Gender:						
	Male	34	61.8		1		
	Female	21	38.2	2			
2	Age of respondent (years):						
	20 & Below	7	12.7				
	21-40	46	83.6			1.9091	2
	41-60	2	3.6	3			
	Above 60	0	0.0				
3	Marital status:						
	Not in marriage relationship (Single or Divorced)	18	32.7				
	Married (including Separated & Widowed)	37	67.3	2	2		
4	Your highest level of education:						
	Others (No formal, Primary & Secondary)	0	0.0				
	Tertiary	55	100.0	2	2		
5	Experience of respondent (years):						
	10 & Below	55	100.0	2		1.000	1
	11 & Above	0	0.0				
6	Length of Stay in the organization (year):						
	1	15	27.3				
	2	0	0.0				
	3	0	0.0				

	4	0	0.0				
	5	0	0.0				
	6	0	0.0			5.3636	6
	7	40	72.7				
	8 & Above	0	0.0	8			
7	Average Monthly Income (Naira):						
	Below 50,000	41	74.5				
	50,000-99,999	6	10.9			1.4727	2
	100,000-149,999	4	7.3				
	150,000-199,999	4	7.3				
	200,000 & Above	0	0.0	5			
8	Your professional affiliation:						
	Engineering	14	25.5				
	Environmental Sciences (Architecture, Building Technology, Estate Management & Quantity Surveying)	41	74.5	2	2		
9	Occupation:						
	Maintenance Officer & Facility Manager	32	58.2		1		
	Top Management (MD & Director)	23	41.8	2			
	SECTION B: SOLAR ARCHITECTURAL CHARACTERISTICS OF THE BUILDING AND ENVIRONMENT						
10	Location of your main power source for your facility (building and environment):						
	Offsite	15	27.3				
	Onsite	40	72.7	2	2		
11	Main source of electricity power for your facility:						
	Public, Private Generator, Community Generator	40	72.7		1		
	Solar or Other renewable energy resources	15	27.3	2			
12	Secondary source of electricity power for your facility:						
	Public, Private Generator,Community Generator	40	72.7		1		
	Solar or Other renewable energy resources	15	27.3	2			
	SECTION C: INDICATORS OF ENERGY PERFORMANCE OF THE BUILDING AND ENVIRONMENT (Single Choice or option is expected in each case where applicable)						
13	How much energy is conserved through the use of the passive strategies?						
	10% & Below						
	11-20%						
	21-30%						
	31-40%						
	41- 50%	26	47.3				
	51-60%	25	45.5			5.6000	6
	61-70%	4	7.3				
	71-80%						
	81-90%						
	91-100%			10			
14	How much energy is subsidized through the use of the active strategies (solar panel)?						
	10% & Below	32	58.2				
	11-20%	8	14.5				
	21-30%						
	31-40%					3.6000	4
	41- 50%						
	51-60%						
	61-70%						
	71-80%						
	81-90%						
	91-100%	15	27.3	10			
15	Scale of preference of Public power supply other than Solar System	55	100.00	10		2.4545	3
16	Scale of preference of Solar System in your facility	55	100.00	10		3.1818	3
17	Regularity of Public power supply other than Solar System	55	100.00	10		1.7273	2

18	Regularity of Solar System in your facility	55	100.00	10	3.1818	3
19	Dependency on Public power supply other than Solar System in your facility	55	100.00	10	7.1818	7
20	Dependency on Solar System in your facility	55	100.00	10	3.7818	4
21	Reliability of Public power supply other than Solar System in your facility	55	100.00	10	2.0182	2
22	Reliability of Solar System in your facility	55	100.00	10	9.0727	9
23	Overall Performance rating of Public Power supply other than Solar System in your facility (building and environment):					
	10% & Below					
	11-20%					
	21-30%					
	31-40%					
	41- 50%	37	67.3			
	51-60%	15	27.3		5.3818	5
	61-70%	3	5.5			
	71-80%					
	81-90%					
	91-100%			10		
24	Overall Performance rating of Solar System in your facility (building and environment):					
	10% & Below					
	11-20%					
	21-30%					
	31-40%					
	41- 50%					
	51-60%					
	61-70%					
	71-80%	4	7.3			
	81-90%	26	47.3	10	8.8818	9
	91-100%	25	45.5			
25	Overall Performance rating of Power supply (& Solar) Systems in your facility (building and environment):					
	10% & Below					
	11-20%					
	21-30%					
	31-40%					
	41- 50%					
	51-60%					
	61-70%	20	36.4			
	71-80%	35	63.6	10	7.6364	8
	81-90%					
	91-100%					

Appendix 3: Correlation analysis [16]

Table 4.4: Pearson Product-moment Correlationsof Solar Energy Efficiency in the Facilities and Relevant Variables

Correlations

		Overall Performance rating of Solar System in your facility (building and environment)	Age of Respondents	Length of Stay in the organisation (year):	Average Monthly Income (Naira):	Occupation	Location of main power source for your facility (building and environment)
Overall Performance rating of Solar System in your facility (building and environment)	Pearson Correlation	1	***.591****	***-.613****	***-.482****	***.431****	***.613****
	Sig. (2-tailed)		***.000***	***.000***	***.000***	***.001***	***.000***
	N	55	***55***	***55***	***55***	***55***	***55***

Correlations

		Overall Performance rating of Solar System in your facility (building and environment)	Main source of electricity power for your facility	Secondary source of electricity power for your facility	Identify incorporation of Solar collector in your building	Identify incorporation of Solar collector in the Surrounding or Neighbourhood:	How much energy is conserved through the use of the passive strategies?
Overall Performance rating of Solar System in your facility (building and environment)	Pearson Correlation	1	***.613*****	***.613*****	***.613*****	***-.613*****	-.076
	Sig. (2-tailed)		***.000***	***.000***	***.000***	***.000***	.582
	N	55	***55***	***55***	***55***	***55***	55

Correlations

		Overall Performance rating of Solar System in your facility (building and environment)	How much energy is subsidised through the use of the active strategies (solar panel)	What is the energy efficiency rating of your facility (building and environment)?	Scale of preference of Public power supply other than Solar System	Scale of preference of Solar System in your facility	Regularity of Public power supply other than Solar System
Overall Performance rating of Solar System in your facility (building and environment)	Pearson Correlation	1	**.572****	**.561****	**-.613****	**.613****	**-.613****
	Sig. (2-tailed)		**.000**	**.000**	**.000**	**.000**	**.000**
	N	55	**55**	**55**	**55**	**55**	**55**

Correlations

		Overall Performance rating of Solar System in your facility (building and environment)	Regularity of Solar System in your facility	Dependency on Public power supply other than Solar System in your facility	Dependency on Solar System in your facility	Reliability of Public power supply other than Solar System in your facility	Reliability of Solar System in your facility
Overall Performance rating of Solar System in your facility (building and environment)	Pearson Correlation	1	***.613*****	***-.661*****	***.564*****	-.193	-.084
	Sig. (2-tailed)		***.000***	***.000***	***.000***	.158	.541
	N	55	***55***	***55***	***55***	55	55

** Correlation is significant at the 0.01 level (2-tailed).
*.Correlation is significant at the 0.05 level (2-tailed).
17 Variables that showed significant levels correlations have their correlation coefficients, sig. and number of cases or observations in bold and italicized.